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The Role of Information Technology in Technology- Mediated Learning: A Review of the Past for the Future

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ABSTRACT

Technology-mediated learning refers to an environment in which the learner's interactions with learning materials, peers, and/or instructors are mediated through information technologies (Alavi and Leidner, 2001). The objective of this paper is to review current research on technology-mediated learning on the basis of a theoretical framework derived from the existing literature. In the theoretical framework, three groups of determinants (human dimension, design dimension, and information technology) are presented that influence students' psychological learning process, which eventually lead to different learning outcomes. The literature review shows that some of the relationships between information technology and other dimensions have been heavily examined (e.g., the influence of a technology feature on learning outcomes), while some others have been ignored (e.g., the influence of IT on student's psychological process). Research questions that can help advance our understanding of technology-mediated learning are also presented and discussed.

Keywords

Technology-mediated learning, Information technology, Education.

INTRODUCTION

Technology-mediated learning refers to an environment in which the learner's interactions with learning materials, peers, and/or instructors are mediated through advanced information technologies (Alavi and Leidner, 2001). In the last decade, the development of technology-mediated learning has advanced dramatically due to the rising demand for postsecondary education and advances in information technologies (e.g., the pervasiveness of networked personal computers in both businesses and homes (Alavi, 2004)). According to Education Industry Association, education has been becoming a $1 trillion industry in US[1]. In particular, the demand for higher education is growing rapidly in the US since an extra two million full-time students are expected to be enrolled by 2010 (Datamonitor, 2004). Similarly, investments on information technology must increase to serve this growing population. Datamonitor (2004) shows that total IT investments on education are expected to reach beyond $9 billion by 2008. However, huge investment in IT for education may not necessarily lead to favorable learning outcomes (Ma et al., 2000), and it is imperative for researchers to develop a complete understanding of the role of IT in the context of technology-mediated learning.

The objective of this paper is to provide a theoretical framework of technology-mediated learning, and use this framework to review the existing research on the relationships between information technologies and instructional, psychological, and environmental factors that enhance learning outcomes. Suggestions for future research are also discussed. This review focuses on learning from instruction in the context of an educational environment and does not include organizational training and informal learning activities.

The remainder of the paper is organized as follows. In the next section, the conceptual framework of technology-mediated learning is proposed based on the extant literature. Then the research emphasis of this article is highlighted, which is the role of information technology and its relationships with other human, instructional, and psychological factors presented in the framework. The following section reviews recently published articles to further illustrate these relationships. The paper

[1] http://www.educationindustry.org/about/overview.php, Accessed date: Feb. 27, 2006.

concludes with the discussions and suggestions of research questions that hold potential to advance our understanding of technology-mediated learning.

THEORETICAL FRAMEWORK OF TECHNOLOGY-MEDIATED LEARNING

While interest in technology-mediated learning is growing rapidly, a comprehensive theoretical framework on relevant constructs and their relationships has not been well developed. Based on the previous research, especially the theory development work by Alavi and Leidner (2001), Piccoli et al. (2001), Benbunan-Fich and Hiltz (2003), and Sharda et al. (2004), we propose a framework as the basis for our literature review (Figure 1). This framework contains three groups of determinants - human dimension, design dimension, and information technology. These determinants individually and collectively influence students' psychological learning process, which eventually affects learning outcome. The framework Is presented in details below.

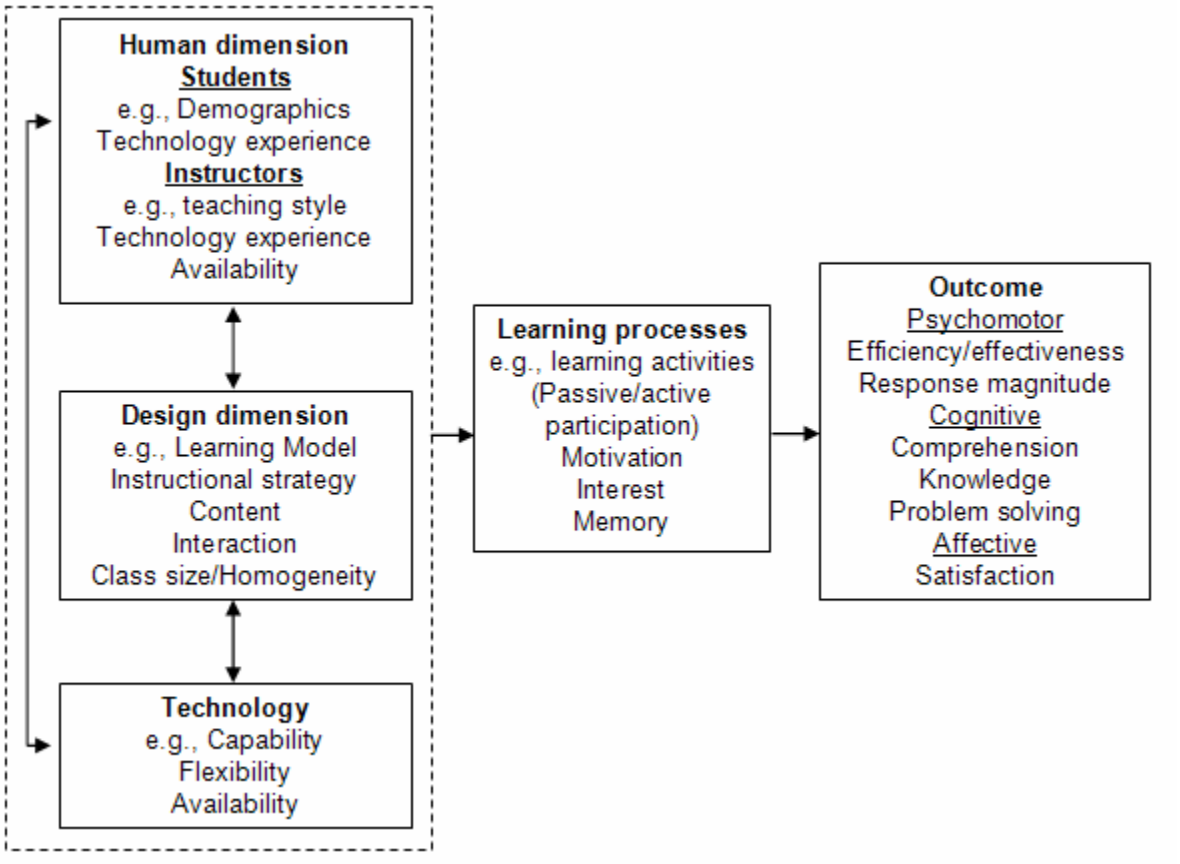

Figure 1. A Theoretical Framework for Technology-Mediated Learning

Human Dimension

Students are the primary participants in any learning environment (Piccoli et al., 2001). Although student characteristics are not included in Alavi and Leidner's (2001) research framework, their moderate effect on learning outcomes has been acknowledged (Alavi and Leidner 2001). Relevant variables on the student dimension include demographics (e.g., age, gender), language, and communication skills (Piccoli et al., 2001). In the technology-mediated learning research, students' technology experience and computer anxiety are most commonly investigated (e.g., Arbaugh and Duray, 2002; Lee, et al., 2001). Because students have to interact extensively with computers, the students who are comfortable with information technology and who have positive attitudes toward it will experience lower levels of anxiety and have better learning outcomes (e.g., Vician and Davis, 2002-2003).

Another key actor in technology-mediated learning is instructor. Instructors' level of technology experience and self-efficacy, in terms of having the ability to control the technology and having a positive attitude toward it, affect student's learning outcomes (Webster and Hackley, 1997; Hantula, 1998). Many people may think that in technology-mediated learning

environments the instructor is less important than in traditional learning environment or even dispensable. However, it is not true. Research shows that instead more efforts are required of instructors because students may perceive the class as being in process whenever they sign in and thus they may ask questions or solicit feedbacks anytime and anywhere. The instructor's availability and engagement will increase the effectiveness of technology-mediated learning environment (Piccoli et al., 2001; Benbunan-Fich and Hiltz, 2003).

Design Dimension

Design dimension includes learning model, instructional strategy, the learning content, the way of interaction, etc (Piccoli et al., 2001). The learning model is the underlying assumption of learning process and will influence the overall design of a learning environment (Piccoli et al., 2001). Five learning models are identified: objectivism, constructivism, collaborativism, cognitive information processing, and socioculturism, with different basic promise, goals, major assumptions and implications for instruction (Leidner and Jarvenpaa, 1995). It is important for researchers to explicitly acknowledge the role of learning model (Leidner and Jarvenpaa, 1995).

Instructional strategy refers to methods used for presenting, sequencing, and synthesizing the learning content (Reigeluth et al., 1994). It will affect how the format of content information is selected, the order of different topics, and the way to establish relationships among these topics (Reigeluth et al., 1994).

Design of ways of interaction also affects learning outcome. In technology-mediated learning, participants' interaction through communication technology can foster effective learning by enabling students to evaluate the course progress and instructional needs, thus complementing the high degree of learner control (Piccoli et al., 2001). To enhance the learning outcomes, the course designer also needs to design appropriate structure and guidance for students to manage the group processes (Oliver and Omari, 2001) and provide instructional infrastructure to support learning activities (Sharda et al., 2004).

Information Technology

Technology quality, reliability and accessibility are important determinants of learning effectiveness and learner satisfaction (e.g., Webster and Hackley, 1997; Arbaugh and Duray, 2002; Marks et al., 2005). Some technologies are best suited to support specific theoretical learning models (Leidner and Jarvenpaa, 1995). Nowadays, the Internet has played a key role in the development of technology-mediated learning by providing scalable connectivity to bridge geographic distance and establishing the browser as a ubiquitous user interface for various distributed learning software applications.

Although technology factor is suggested to be included in design dimension (e.g., Piccoli et al., 2001), the framework presented here is trying to highlight the interaction between technology and design dimension (e.g., Alavi and Leidner, 2001; Benbunan-Fich and Hiltz, 2003), and technology and human dimension. Technology itself does not produce desired learning outcomes, but the interaction between technology features, human and design dimensions might impact the students' psychological learning processes and subsequently the learning outcomes (as illustrated in figure 1).

Learning Processes

Learning processes include both psychological processes (Alavi and Leidner, 2001) and actual learning behaviors (Benbunan-Fich and Hiltz, 2003). Psychological processes refer to states within the student that are involved in learning, which include the learner's cognitive and information processing activities, motivation, interest, and cognitive structures (e.g., memory) (Alavi and Leidner, 2001). Due to the complexity of human's psychological processes, this important mediator has been missing in major body of literatures on technology-mediated learning and has been ignored in theoretical frameworks provided by Piccoli et al. (2001) and Sharda et al. (2004). Many studies have directly focused on the effect of technology feature on learning outcome (e.g., Alavi et al, 2002); few studies have touched motivation, interest, or investigated learner's cognition and cognitive structures (e.g., Benbunan-Fich and Hiltz, 2003; Stafford, 2005).

Learning Outcomes

Learning outcome is a key dependent variable. The purpose of learning is to acquire knowledge and increase the capability to take effective action, but knowledge and capability can not be directly measured. Only the action and performance resulting from learning can be observed and measured (Alavi and Leidner, 2001). In addition to the cognitive outcomes of learning, another type of outcome is learners' affective reactions to the learning process (e.g., learner satisfaction). According to Sharda et al (2004), learning outcome can be classified into three groups: psychomotor outcomes, cognitive outcomes, and affective outcomes. The psychomotor outcomes include efficiency, accuracy, and response magnitude; the cognitive outcomes include knowledge, comprehension, application, and analysis; the affective outcomes include students' perception of satisfaction, attitude, and appreciation for the learning experience.

This framework presents an integrated view of the topic of technology-mediated learning and introduces concepts and their relationships that could be studied. For IS researchers, the role of information technology in technology-mediated learning is emphasized and intensively investigated. However, as Alavi and Leidner (2001) point out in their research commentary, IS researchers should shift their focus from specifying simple cause-effect relationships between observable technology features (e.g., with or without a GSS) and learning outcome. Instead, they should form relationship between technology and other constructs. In other words, they should answer the question about how information technology enhances learning and learning process by interaction with human dimension and design dimension (Alavi and Leidner 2001). In next section, studies conducted after Alavi and Leidner's call for greater depth of research (2001) are reviewed to see to what extent IS researchers have responded to this call.

THE ROLE OF INFORMATION TECHNOLOGY

Technology-mediated learning involves multi-discipline research. Studies conducted in educational psychology and pedagogy fields are not included in this review because they investigate the relationship that are not directly related to information technology (i.e., relationships between human dimension and design dimension, and their influence on learning and learning outcomes, illustrated as thin lines in Figure 2). Only studies investigating relationships involving technology are discussed here. That is, we focus on four groups of relationships immediately involving IT: the interaction between IT and human dimension, IT and design dimension, the influence of IT on learning processes, and the influence of IT on learning outcomes (illustrated as thick lines in Figure 2).

Alavi and Leidner (2001) provided an excellent review of the state of research in the field prior to its publication. In this paper, we review articles on these topics to summarize what has been done following their review and to identify gaps for future research. More than forty articles were collected by searching the following key words in the database provided by ProQuest: technology-mediated learning, computer-mediated learning, technology-supported learning, virtual learning, web-based learning, online education, computer-based collaborate learning, and distance learning. They were further examined and categorized according to their relevance to the four groups of relationships emphasized in this paper.

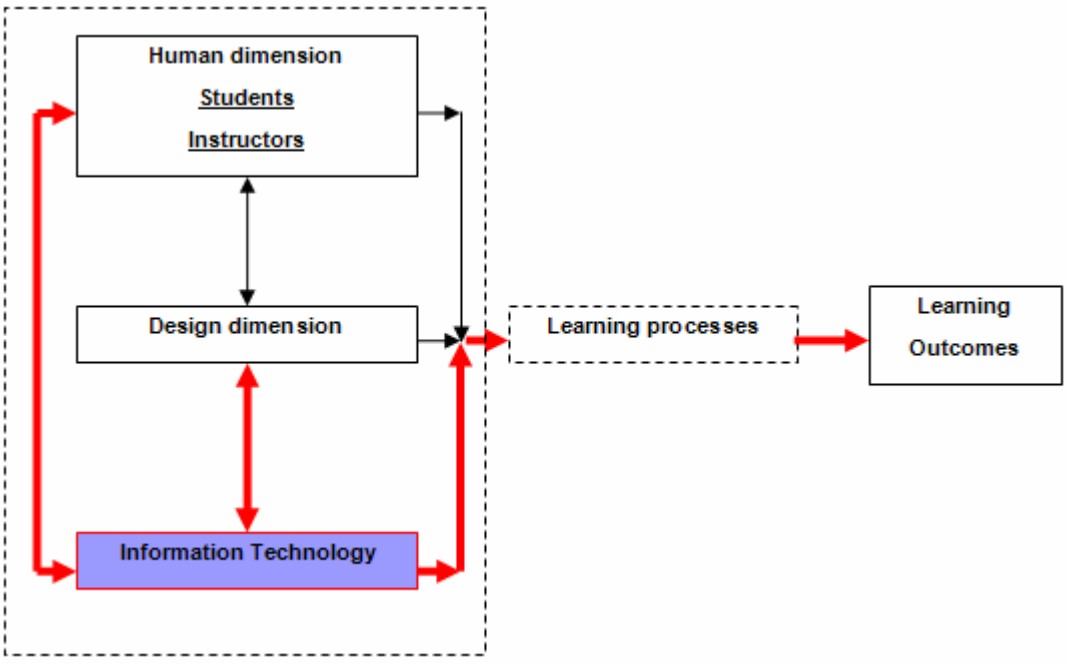

Figure 2. The Relationship between Information Technology and Other Constructs

IT and Human Dimension

The existing literature has studied the relationship between individual characteristics and demographics and usage of information technology, and their effect on learning outcome. Although research shows no connection between student age, gender, GPA and their choice of a web-based course or a traditional course on the same topic (Parnell and Carraher, 2003), computer anxiety and communication apprehension have been found significantly related to usage and outcome of computer technologies for learning purposes (Vician and Davis, 2002-2003). Prior studies have shown that technology experience is a

strong predictor of student's perception of technology usage (e.g., Thompson et al., 1994; Atkinson and Kydd, 1997), and more experienced students visit more frequently and stay longer in the course site (Lee, et al., 2001). However, recent studies present mixed findings on the relationship between student experience and course satisfaction. For example, one study confirms that more experienced on-line students are more satisfied with their course delivery medium (Arbaugh and Duray, 2002), while another study reports no difference in perceived learning and satisfaction (Marks et al., 2005).

The role of instructor is shifting from the "sage on the stage" to a "guide by the side" (Gibson, 1996). The importance of instructor in a technology-mediated learning environment has been reported in many studies (Coppola et al., 2002; Easton, 2003; Martins and Kellermanns, 2004). The outcomes of online courses can be improved when professors support the growth of online learning communities by making themselves available online to interact with students (Benbunan-Fich and Hiltz, 2003), seeking and encouraging student involvement in discussion (McFadzean and McKenzie, 2001; Marks et al., 2005). These instructor-initiated activities are most valued by students (Frey et al., 2003).

IT and Design Dimension

Information technology can be integrated into course design in two different but overlapping ways: transmit learning content or support communication between instructor and students or among students (Benbunan-Fich, 2002). As a content-transmission tool, technology can complement or replace the traditional role of printed materials and provide richer and dynamic information display, animation, and computer-based tutorials (e.g., Seal and Przasnyski, 2003).

As a tool that supports communication, technology can facilitate interactions between learners (Hay et al, 2004), extend instructor availability beyond class times and office hours, and accomplish administrative activities such as the distribution of learning materials (Benbunan-Fich, 2002). Emails on lecture notes and assignment are used intensively by both instructors and students and is perceived as being able to increase productivity (Zhao et al, 2003). Although the interaction between students is important in predicting effectiveness of courses (Hay et al, 2004), the instructor-student interaction (when both exist) is more important, twice than of student-student interaction (Marks et al., 2005).

As we have discussed earlier, different learning models require different ways to implement information technologies in course design (Leidner and Jarvenpaa, 1995). It is hard to say which learning model is more effective. The fit between technologies and students' learning models is more important. Based on this contingency perspective, Benbunan-Fich (2002) provides a three-dimension conceptual model by combining learning models (objectivist or constructivist), time (synchronous or asynchronous), and place dispersion (proximate or dispersed). Each cube represents a learning context and implies different educational applications of IT. For example, in traditional classroom (same time, same place, and objectivist learning model) the presentation technology and computerized tutorials can mediate traditional lectures to increase the efficiency of knowledge transmission. In asynchronous/dispersed/constructivist learning contexts, the IT applications range from email to asynchronous learning networks to support constructive learning anytime and anywhere.

IT and Learning Processes

Technology can influence learning by facilitating cognitive information processing activities such as search, scanning, transformation, or comparison of information (Alavi and Leidner, 2001). However, five years after Alavi and Leidner's call for greater depth of research on students' psychological learning process, related studies are lacking.

Among limited number of studies, one most frequently investigated variable is learner's motivations. Higher motivation leads to greater perceived learning (Benbunan-Fich and Hiltz, 2003). Stafford (2005) identifies three dimensions of Internet usage motivations: content, process and social motivation. The online course content is highly sought after by students with content motivation. Students are also motivated to use Internet to offset the lack of social interaction found in normal classrooms. The students' process motivations diverge into searching versus browsing in support of learning.

IT and Leaning Outcomes

Direct investigation on the success of IT implementation in learning environment remains a popular topic. The literature has compared the learning outcomes between traditional and online course (e.g., McCray, 2000; Hay et al., 2004; Chou, 2005), and recently the hybrid course (e.g., Benbunan-Fich and Hiltz, 2003). However, mixed findings are often reported and there is no clear conclusion of this research question.

Another stream of research compares specific technologies and their impact on learning outcomes. Alavi et al. (2002) employ a quasi-experimental field study to compare learning effectiveness between two types of information technologies: a simple e-mail and listserv capability and a more sophisticated GSS. Interestingly, the learning outcome of students using e-mail was better than of the students using GSS. In the post-hoc analysis the authors find that the students using e-mail focus more on the learning task and the students using GSS focus more on technology sense-making. This is a clear example of the mediate

effect of learners' actual behavior on learning outcomes. In another study conducted in a problem-based learning environment, researchers find that learners using GSS have more initiated ideas, fewer questions, and better feedback than those in non-GSS supported one (Kwok, et al. 2002). However, it seems still too arbitrary to make the conclusion that simple application of GSS leads to better learning outcomes. According to the theoretical framework (Figure 1), positive learning outcome may be due to a match between GSS and collaborative learning model or due to GSS being able to provide support to participations.

The third group of research looks at more general technology features such as flexibility, convenience and availability, and their impacts on affective learning outcome (e.g., satisfaction). For example, perceived flexibility of the technologies used for content delivery is significantly associated with perceived learning and satisfaction (e.g., Arbaugh and Duray, 2002; Marks et al., 2005). Higher perception of convenience of access to learning activities leads to better perception of learning (Benbunan-Fich and Hiltz, 2003).

DISCUSSIONS AND FUTURE RESEARCH

In the last section, previous studies on technology-mediated learning conducted in the past five years are reviewed. The review shows that we are still in the early stage of investigating technology-mediated learning, and much work remains to be done. The literature to date has surfaced and framed many of the issues and challenges associated with technology-mediated learning environment. Below we discuss relevant issues and, more importantly, give suggestions for future research.

First, the homogeneity of the research subject (school students) might be an issue since most studies focus on the educational context and do not involve organizational settings. As information technology (e.g., personal computer) has become increasingly popular, the young generation has experienced an increasing degree of technology use in their coursework and even daily life. Age different among students is comparatively small and individual differences of cognitions such as technology experience and computer anxiety might be less salient then the mass population. Thus, the external validity of the studies using students as research subjects is limited. We must be careful when generalizing the findings drawn from school setting to organizational setting.

Second, the link between IT and course design has demonstrated as one of the key relationships in technology-mediated learning. Technologies provide enhanced capabilities for the execution of instructional strategies and more effective and efficient content delivery. At a higher level, technologies also enable the implementation of different learning models such as collaborativism (Leidner and Jarvenpaa, 1995). Collaborative learning, especially computer supported collaborative learning, has drawn a substantial amount of research attention (Williams and Roberts, 2002). It redefines the role of learner as more active in his/her own learning and the role of instructor as a facilitator and resource guide who considers not only the cognitive but also the social nature of learning (Borthick et al, 2003).

Third, more research should *focus on how to build an appropriate IT infrastructure to support and facilitate the interaction between instructor and students and among students.* Although the importance of student-student and student-instructor interactions has been reinforced in many research (e.g., Hay et al, 2004; Marks et al., 2005), the role of information technology should not be limited as a simple enabler of more communication and interaction channels. Some researchers suggest that it should provide more structure and guidance to manage group activities (Oliver and Omari, 2001), plan and support group practices (McFadzean and McKenzie, 2001), and establish communication policies to govern the conversation among 'agents' (Leung and Li, 2004). Collaborator plays a key role in collaborative learning but sometimes it is difficult for a human collaborator to track multiple teams working at different times with members located in different places. Therefore there is a growing interest in developing intelligent systems that support this facilitation process, such as computer coach (Constantino-Gonzalez and Suthers, 2003). Other developments include collaborative learning systems and immersive presence technologies which integrate technologies and human-computer interface principles (Sharda et al., 2004).

Fourth, although collaboratism has been well represented in the existing research, the other two learning models defined by Leidner and Jarvenpaa (1995) (i.e., cognitive information processing and socioculturism) have not been investigated. Thus, future research should address the question: *What information technology can do for these two learning models?* An ideal learning environment should be able to identify learner's need and customize solutions for diverse learner communities. *Personalized learning environment* (e.g., Xu et al. 2005) could also be a future direction of research. Also, *how to transform conventional study material to a form that optimal for new learning models* is also worthy investigation (McMurray and Dunlop, 1999).

Fifth, *how the technology features and course design influence learner's cognitive and information processing activities, motivation, interest and cognitive structures* still remains as an important but poorly understood question. IS researchers are facing the challenge to cooperate with researchers in other fields and should learn more from reference disciplines such as educational psychology and pedagogy.

Finally, as we have mentioned earlier in the paper, this review focuses on learning from instruction in the context of an educational environment and does not include organizational training and informal learning activities. The investigation on technology-mediated learning in organizational settings and/or the comparison between these two different settings will be interesting research topics for future research.

CONCLUSION

Five years after Alavi and Leidner's research commentary on technology-mediated learning, developments of this line of research in both theory and practice are prominent. Although empirical test is necessary to validate the conceptual model proposed above, this review has made some contributions to the literature. It provides an integrated framework that explicates the configuration of relationships among technology, human and design dimensions, learning activities, and psychological learning processes. It shows that our knowledge on this topic is still limited and some constructs such as learner's psychological learning processes are far from being well developed. This research could serve as a step stone for future research. Research questions that hold potential to advance our understanding of technology-mediated learning are provided.

Continuous improvement in IT and IT-related innovation are making technology-mediated learning an increasingly viable alternative to traditional face-to-face learning approach. Not simply as a means of reducing the cost of education, technology has to be more than add-ons to existing learning processes (Hodgson and Watland, 2004). New technologies and learning theories must together serve as a catalyst for fundamental rethinking of what learning can be and should be (Fisher and Scharff, 1998). The underling assumptions of traditional learning have to be challenged and the educational institutions should provide more institutional support to the instructional innovation. Both the instructor and students need to be involved in the planning and designing processes of this new learning environment to ensure positive learning outcomes. By considering all the factors and issues, technology-mediated learning can be very successful and highly beneficial.

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